PLEASE SEE
ENCLOSURE

TRANSACTIONS
OF THE
ILLUMINATING ENGINEERING SOCIETY

FOUNDED IN LONDON 1909

INCORPORATED 1930

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SESSION 1946—1947

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The Illuminating Engineering Society

(Founded in London, 1909; Incorporated, 1930)

32, VICTORIA STREET, LONDON, S.W.1

June, 1947.

DEAR MEMBER,

The Development Committee of the Illuminating Engineering Society is considering means whereby the prestige of the Society and its usefulness to members might be enhanced and the special interests of the Society might be served. It is felt that there are many ways in which members might actively co-operate in developing the activities of the Society and also that there are many members who would gladly offer their services in this connection.

It is proposed therefore to compile a record giving details of the special knowledge and capabilities possessed by members so that their services might be enlisted when appropriate opportunities are presented. The proposed record would also give a useful indication to the Development Committee of the lines on which immediate development might be planned.

Members are accordingly invited to complete the following questionnaire and return it to the Secretary at 32, Victoria Street, London, S.W.1.

A. B. Wester

Hon. Secretary.

Members are requested to fill in their answers to the following questions and return this sheet to the Secretary of the Illuminating Engineering Society, 32, Victoria Street, London, S.W.1. Additional or supplementary matter may be written in the space available or on a separate sheet attached.

1. Name.

2. Address and Telephone No. (*a*) Private (*b*) Business.

3. Nature of Occupation.

4. Date of Birth.

5. Any other professional or scientific bodies with which you are connected.

P.T.O.

6. Please signify whether prepared to help in any of the following ways :—

(*a*) by serving on I.E.S. Committees or Panels either in London or at your local Centre or Group, or undertaking secretarial or statistical work on behalf of such Committees or Panels.

(*b*) by lecturing on lighting matters

(i) to other bodies

(ii) to school children

(iii) in connection with courses of instruction at technical colleges, etc.

(*c*) by giving publicity to the activities of the Society by reporting meetings to the Press, etc.

(*d*) by helping with the organisation of Sessional or Informal Meetings of Visits, or helping with administrative work

(i) in London

(ii) at your local Centre or Group

(*e*) by writing articles on any particular aspect of lighting

(i) for the technical press, etc.

(ii) for non-technical press, youth magazines, etc.

(*f*) by taking part in research, detailed investigation, collection of data, etc., in relation to particular lighting problems or industrial processes.

(In this connection please state any aspect of lighting in which you have specialised, or lighting problems in which you are particularly interested.)

(*g*) by helping to enrol new members.

7. Please state if you have any specialised knowledge which might be of value to the Society either at the present time or possibly at some future date.

Signature of Member.....

Date.....

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International Relations in Illuminating Engineering*

By Dr. N. A. HALBERTSMA†

To make a speech on the subject "Which is the brightest nation?" in which one nation after the other passes through the limelight, would certainly be a most delicate task. Yet it was undertaken by a delegate at a banquet in the United States, at the 7th Session of the International Commission on Illumination. The audience passed through moments of tense expectation in awaiting the verdict, but the strain relaxed when the speaker announced the answer "The brightest nation, ladies and gentlemen, in my opinion is *illumination*."

It may be true that illumination, being the brightest nation, is far above rivalry, jealousy and sensitivity, which so often interfere with international relations. This may explain why I can make, at the beginning of my address, the following statement, which, in these days, may sound like music in your ears: it is that international relations in Illuminating Engineering always have been excellent and they are still so at present.

Looking back to the beginning of this century we find that the international relations between the experts of gas, amongst themselves, and the international relations between the electrical men were far better than the mutual relations between these two groups. It was the International Congress of Electricians in Geneva, in 1896, which established our system of photometric units, worked out by Blondel. On the other hand the International Gas Congress in Paris in 1900 emphasised the need for more accurate methods of determining the candle-power of gas light sources, and this led to the formation of the International Photometric Commission, which held three meetings in Zürich in 1903, 1907 and 1911.

By 1911, Dr. C. C. Paterson, one of its members, realised that they were dealing with only a small fraction of the problems in the field of illumination. Both the incandescent mantle and the tungsten filament lamp had made good lighting available at that time, and both groups, in spite of the rivalry between them, were brought together in 1909 in the Illuminating Engineering Society by Mr. Leon Gaster, who did so much to promote good relations, both national and international.

It was the natural consequence of this development, which led to the foundation of Illuminating Engineering Societies in the United States (1906) and in Germany (1912). The International Photometric Commission broadened its scope in 1913, when meeting in Berlin, firstly to bring about international understanding and agreement on lighting matters, where this was deemed desirable, and secondly to study matters connected with illumination. Its name was therefore altered to the International Commission on Illumination (I.C.I.). From that year, Sir Clifford C. Paterson has been acting as its hon. secretary, a service which was only interrupted by his presidency from 1928-1935.

The new Commission in the beginning was not very fortunate. The first world war came and international relations stopped. Only after an interval of 8 years could the I.C.I. hold its first technical meeting in Paris (1921). As the I.C.I. considered itself the successor of the International Photometrical Commission, this meeting was called the 5th Session. Only 22 delegates from 5

* Presented at a meeting of the Society held on May 13, 1947.

† President of the International Commission on Illumination.

XUM

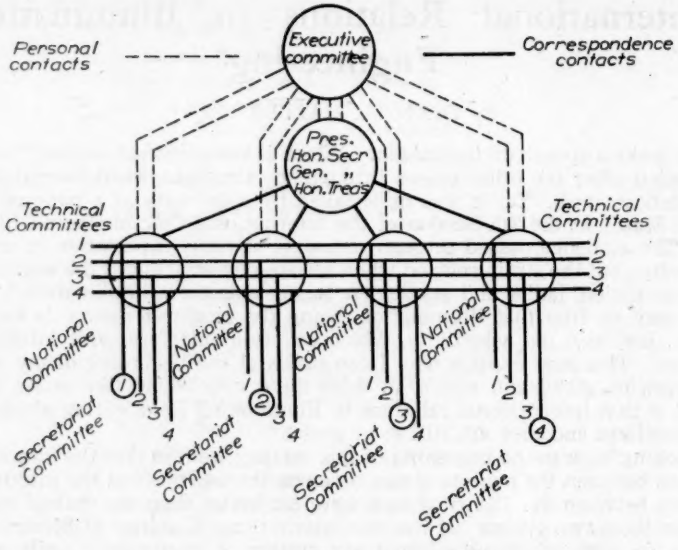

Fig. 1.

countries (France, Great Britain, Italy, Switzerland and the United States) and 2 guests from Belgium and Spain took part in the discussions, which were mainly related to the primary standards of light, definitions and units, heterochromatic photometry and factory lighting.

Four technical committees were appointed, and 3 years later (1924) they presented reports to the 6th Session, which was held in Geneva. On this occasion 34 delegates from 5 countries attended, a meagre record for an International Commission, but the considerable number of 25 papers presented by individuals, besides the 4 official reports, added to the value of the meeting. It was after this meeting that Mr. E. P. Hyde, who had succeeded the first president, Monsieur Vautier, suggested that the time had come for Germany and Austria to join the I.C.I. again as full members and attend an intermediate technical meeting at Bellagio in 1927. Belgium, the Netherlands and Japan were represented there for the first time as members and the U.S.S.R. sent an observer. These 11 countries with 68 delegates made an impressive international gathering and the 46 papers presented covered nearly every section of the lighting field. This meeting, by the contacts it established between representatives of different nations, paved the way for the success of the 7th Session, which was held the following year (1928), at Saranac Inn (U.S.A.).

At this session the Statutes were redrafted into their present form, the purpose of the Commission being described as follows:

1. To provide an International Forum for all matters relating to the science and art of illumination;
2. To promote by all appropriate means the study of such matters;
3. To provide for the interchange of information between the different countries;
4. To agree upon, and to publish, international recommendations.

So the primary function of the I.C.I. is not standardisation—especially

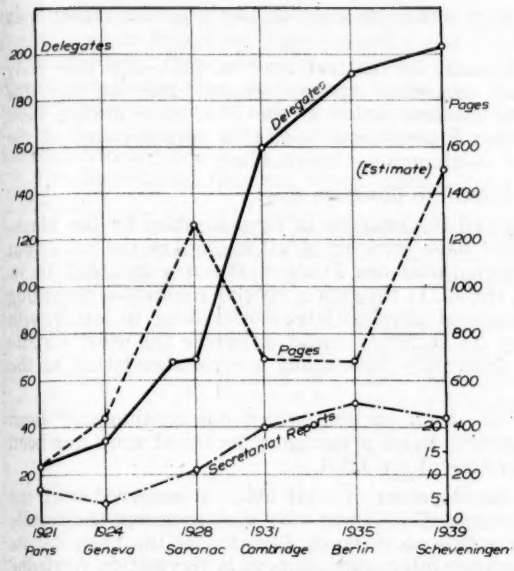

Fig. 2.

commodity standardisation —but the discussion and dissemination of scientific and technical information.

The difference between an Illuminating Engineering Congress and a session of the I.C.I. was clearly set forth in 1928 in a paper by Mr. P. Good entitled "International Organisation in the Technical Field." An international congress can only provide an occasional contact for members of the same profession, whereas the I.C.I. is a permanent organisation. Even if its sessions are held only once every three years, the work of its technical committees goes on in the years between. Following the example set by the I.E.C., the work of the technical committees is based upon the existence of National Committees on Illumination, which are images of the I.C.I., and which should have under them technical committees to study the various subjects dealt with by the I.C.I. Each country can take responsibility for one (or more) of these subjects and provide the "Secretariat Committee" for that subject.

Fig. 1 shows this scheme as it would operate for four countries and four technical subjects. In this way a considerable burden is taken away from the Central Bureau of the General Secretary, Mr. J. S. Preston, and delegated to the various National Committees. One subject only, "Units and Standards," is being handled by the Central Bureau directly. From the very beginning the work of the Central Bureau has been done at the National Physical Laboratory in Teddington, and great credit is due to Dr. J. W. T. Walsh, Dr. H. Buckley, Dr. W. S. Stiles, and Mr. J. S. Preston, who have served the I.C.I. as General Secretaries, thus ensuring continuity of the work.

So, as Mr. Good has put it, the National Committee becomes a working centre which must assume the responsibility for the effective progress of the work on a certain subject, and when functioning thus it must be careful to remain entirely impartial. It collects the views of its own National Committee in the same way as those of others, circulates them, prepares reports and agendas and arranges for the meetings of the technical sub-committees concerned, acting generally as a catalyser by continually urging each country to carry out its part of the agreed programme.

Fig. 2 shows the number of delegates at the six sessions held between 1921 and 1939, the number of pages of the Proceedings (Receuil des Travaux et Comptes Rendus des Séances), and the numbers of Secretariat Reports. These diagrams give the impression of sound growth and may be taken as a

proof that the I.C.I. is being more and more accepted as the authoritative body in the field of illumination.

One of the reasons for this may be the fact that the I.C.I. is a free body and not an inter-government concern. Another reason may be that the Executive Committee and the Administration of the I.C.I. have always been willing to co-operate with other international bodies, in consideration of the fact that a certain amount of overlapping is inevitable.

A few examples may be helpful to illustrate this:

The primary unit of light and the progress of its realisation by the black-body as a fundamental standard have come up at all sessions of the I.C.I., but when in 1931 the Bureau International des Poids et Mesures included in its programme the unit of light, the I.C.I., through a special committee including delegates of the four large national physical laboratories, kept in touch with the B.I.P.M., for this body by its authority could introduce the New Candle officially, whereas the I.C.I. could only have made a recommendation to the National Committees.

Automobile lighting has also been an item which has continuously been dealt with by the I.C.I. In this way much preparatory technical work has been done for the automobile committee of the I.S.A.

After 1931 such a rapid development of civil aviation occurred that the Conférence Internationale Aérienne (C.I.A.) was very glad to accept the results of the work of the I.C.I. Committee on Aviation Lighting as the basis for its recommendations to the Conférence Internationale pour la Navigation Aérienne (C.I.N.A.). To accelerate this work, the I.C.I. Committee on Aviation Lighting held an intermediate meeting in Zurich in 1932.

In 1924 the I.C.I. agreed upon a table of provisional values for the relative luminosity factor, which have since been incorporated in the Vocabulary issued by the I.C.I. in 1939. This Vocabulary is more than a list, it is a technical dictionary which contains 95 terms used in illuminating engineering given in four languages. It is a great help for those who want to study literature appearing in a foreign language. Its value is greatly enhanced by the fact that it contains full definitions in addition to the terms. A more extensive list, giving for 850 terms the equivalent expressions in Dutch, German, English, French, and Esperanto, has been prepared by the Dutch National Committee. Its second edition appeared in 1941.

As a last example of the work of the I.C.I. I would like to mention the recommendations on standard conditions for colorimetry, which are based on the excellent work of the British Secretariat Committee, and which led to the I.C.I. trichromatic colorimetric system.

A few months after the very successful tenth session had been held in June, 1939, in Scheveningen, the second world war stopped the work of the I.C.I. entirely, and there was a further interruption of nearly eight years before the I.C.I. could take up its work again.

The present situation of the I.C.I. is very much like that in 1921. The effective membership, the number of National Committees operating, has become much smaller. From the countries which belonged to the "Axis," only Italy seems to have taken up the National Committee work again. Contact with this country, although not yet normal, has become easier since it has signed the Peace Treaty, and I hope that the enthusiastic president, Professor Perucca, may succeed in keeping the Italian National Committee on Illumination going and growing. Sweden reorganised its National Committee at the end of 1946,

but the Bureau of the I.C.I. is still without any news from the National Committees in Argentine, Spain, Austria and Poland.

Therefore it has proved necessary to make a temporary reallocation of Secretariat Committees, and, as the list in Fig. 3 shows, the full burden of 24 subjects now rests upon eight countries only. This situation is not very satisfactory. especially as the task of any secretariat committee in itself is now heavier than in the past.

The Secretariat Reports, which always have been a valuable source of

LIST OF SECRETARIAT COMMITTEES

Group	No.	Subject	Country
Photometry	1A	Vocabulary	Switzerland
	1B	Definitions and Symbols	France
	2, 3	Units and Standards	Central Bur.
	4	Light and Vision	France
	5	Visual } Photometry	France
	6	Physical } Photometry	Switzerland
	7	Colorimetry	United States
Sources and Accessories	21	Light Sources	Great Britain
	22A	Diffusing Materials	Czechoslov.
	22B	Classification Luminaires	Belgium
Applications	23A	Street Lighting	United States
	23B	Automobile Lighting	Italy
	25	Museum Lighting*	France
	26A	Aviation (Ground) Lighting	Netherlands
	26B	,, (Aircraft) ,,	France
	26C	Traffic Signals	Great Britain
	26D	Calc. of Projector Systems	Great Britain
	27	Natural Daylight	Great Britain
	29	Mine Lighting	Belgium
U.V.	41	Ultraviolet Radiation	Netherlands
Miscellaneous	62A	Lighting Education	France
	62B	,, Practice	United States
	62C	Voltage Variations	Italy
	62D	Cinema Lighting**	United States
	62E	Theatre Lighting	Great Britain

*Architectural lighting generally. ** Incl. Studio Lighting.

Fig. 3.

information, will become much more so when they cover that period of ten years, from 1938-1947, in which the distribution of technical literature has been very irregular. Many countries have for five years been cut off entirely from the supply of books and technical and scientific journals in the English language. Libraries are suffering from missing numbers and missing volumes. But even if these empty places on the book-shelves could be filled, illuminating engineers

in those countries would have no time to go through all the literature which appeared since they received their last copies in 1939!

There must be everywhere in the world a strong need for a good survey, including abstracts of that literature of the period 1938-47, and as far as light and illumination are concerned, I believe that the Secretariat Reports for the eleventh I.C.I. Session, to be held in Paris in 1948, may answer this need, provided the Secretariat Committees are prepared to do the extra work and to do it well.

These reports, in order to be a source for easy reference, should be made in a more uniform way, and provided with a subject and author index and with a complete list of literature from 1938-1947. In abstracting papers and articles of greater importance illustrations and diagrams should be used more extensively. The replies to questionnaires sent out by the Secretariat Committee could also be presented in a more attractive way by diagrams.

It has always been customary to issue Secretariat Reports shortly before the session in the form of preprints. I always tried to get hold of a full collection of these preprints, for I knew that it generally took a couple of years for the complete Proceedings of a Session, including the Secretariat Reports, to appear in print.

But if the Secretariat Reports are prepared in such a way as I suggest, they will certainly fill a complete volume, and in that case I see no reason why this volume should not be available a short time before the Session. This would save a considerable amount of paper, as preprints in the past were printed only on one side of the paper. I know that this can only be done by special efforts of the Secretariat Committees and of the General Secretary as the chief editor of such a volume, but it seems to me that these efforts will result in a great service being rendered to the whole profession, especially in those countries which have suffered much from the war.

Let me say here that the contribution of any National Committee to the work of the I.C.I. should never be evaluated by the number of Secretariat Committees nor by the relative importance of the subjects, but merely by the quality of the work, and by the care with which the replies to questionnaires have been analysed, and the report has been made.

Whilst speaking about the importance of the Proceedings of the I.C.I. as an always up-to-date source of information I would like to add a few words about the adventures of the Proceedings of the last meeting in Scheveningen. The German National Committee wanted to make an effort to publish them in three volumes during the war. Volume I (705 pages), the Secretariat Reports, was issued in 1942. It really contains a wealth of information, which could have been made more accessible if a subject index and author index had been added. Volume II (385 pages), published in 1943, contains 28 papers, presented by individuals at Scheveningen. Volume III was to contain the minutes of the meetings, the discussions, and the recommendations, but it never came off the press, as the manuscripts were carefully hidden in a vault of the K.E.M.A. laboratory at Arnhem, near the office of the secretary of the Dutch National Committee. This office, situated between Arnhem and Oosterbeek, was very near the place of the stiffest fighting in September, 1944. It was afterwards completely robbed of its inventory, but the documents in the vault escaped the looters' attention and will soon be in England. In the meantime the U.S. National Committee had prepared and published in 1943 a "condensed, unofficial version" of the 1939 Proceedings of the I.C.I.

It has been discovered that a considerable number of Volumes I and II are

still in stock in Vienna, where they were printed, and the General Secretary hopes to be successful in getting them over to the Central Bureau.

In the near future there will be the 11th Session, originally planned for Paris in 1942. The French National Committee has repeated its gracious invitation, and the I.C.I. has been glad to accept that invitation for September, 1948. Nine years will then have passed since lighting men from all over the world met in Scheveningen. This will mean considerable changes. Many old friends will not come back. A younger generation will for the first time attend an international meeting on illumination. I hope they will read this short survey of the way in which problems have been dealt with successfully by the Executive Committee and the Bureau.

It is especially for these younger friends that I would like to say something about the future of the I.C.I. These are things which the older generation knows well.

What should be the aims of the I.C.I.? It should maintain its *international* authority and prestige. It should maintain its authority and prestige towards the National Committees. It should aim at the *extension* of membership to *all* countries. It should be ready to adapt itself to *new circumstances.*

International Authority

The I.C.I. should do neither *more* nor *less* than it is expected to do. For example, the I.C.I. would not fulfil its purpose if it presented only Secretariat Reports at the Sessions, or if there were only papers by individuals. The right balance must be maintained, by considerations of time, efficiency and cost. I need not stress the fact that papers presented to such an international gathering of specialists as an I.C.I. Session should be of the highest quality, original, short, and to the point. They should cover subjects of actual value and of international interest. A paper on the lighting of factories for wooden shoes may be very good for the I.E.S. in Holland, but it would lack international technical interest. Any paper already presented to an Illuminating Engineering Society should be dealt with in the Secretariat Report; it should not be repeated, even in an abbreviated form, at a Session of the I.C.I. We may never expect that everybody attending I.C.I. Sessions will understand the official languages used with the same ease. This is a serious reason for avoiding complicated phrases and for aiming at simplicity of expression.

The I.C.I. decided at Scheveningen to leave the responsibility for the quality of the papers with the National Committees. This was an important decision, and a good one. The I.C.I. believes that it will lead to a better selection if every National Committee is allotted a definite space in the printed Proceedings.

A factor which may also have largely contributed to the International authority of the I.C.I. is the fact that it has never tried to enforce any resolutions, even when taken unanimously, but that it has put the results of its work into the shape of recommendations, leaving it to the National Committees to put these recommendations before those national bodies or officials who may act upon them as they so desire.

National Authority

Good relations between the I.C.I. and the National Committees are of the greatest importance. The I.C.I. depends upon the willingness of the National Committees to do Secretariat work; it is also entirely dependent upon the National Committee for making known in a country the results of the I.C.I. work, notably its recommendations. The delegates are the link between the National Committee and the I.C.I., but they are also persons whom the

National Committee should trust. If the delegates of a country on the Executive Committee, after consultation with their fellow delegates, give their vote to a recommendation, the National Committee should only in exceptional cases use their right to alter such a vote within the specified period of four months.

I must refer again to the paper by Mr. P. Good where he says "the recommendations are intended for international use, and national committees who have given agreement to such recommendations, even though they have found themselves unable to use them in their own country, should place no obstacle in the way of their use in international transactions."

Much of the national authority of the I.C.I. depends upon the way in which the returning delegates inform their country, through the technical organisations and the technical press about the work of the I.C.I.

Extension of Membership

Fig. 4 is a list showing the participation of the various countries in the sessions between 1921 and 1939. Numbers in brackets refer to guests or observers, not backed by a National Committee. The number of countries in this list is impressive, yet many names could be added. There are empty spaces, which show that many countries, including several important ones, have not taken a continuous interest in the I.C.I.'s work. Have the delegates of such countries not grasped sufficiently the difference between a congress and the

Attendance from :	1921	1924	1927	1928	1931	1935	1939	Total
Argentina					1	2		3
Austria			1	3	4	7		15
Belgium	(1)		1		7	5	5	19
Brazil				(2)				2
Canada					(2)			2
Czechoslovakia ...					6	8		14
Denmark							(1)	1
France	9	6	14	10	29	16	21	105
Germany			7	9	16	42	32	106
Great Britain ...	7	9	12	16	20	49	51	164
Hungary						2	7	9
Irish Free State ...					(1)		(1)	2
Italy	2	2	16		15	3	11	49
Japan			1	6	8	7	2	24
Netherlands ...			2	1	8	8	40	59
New Zealand ...					(2)			2
Poland					3	12	6	21
South Africa ...					(1)			1
Spain	(1)				(3)	1	1	6
Sweden				1	5	4	4	14
Switzerland ...	1	10	7	4	11	11	10	54
U.S.A.	3	7	6	15	16	15	11	73
U.S.S.R.			(1)	(2)	(1)			4
Total	24	34	68	69	159	192	203	749
Number of Nations	7	5	11	11	20	16	15	

Fig. 4.

continuous work of the I.C.I., or have we failed to send them home with the idea that this work is of permanent importance to their own country also?

I am glad to say that some countries have lately inquired about the conditions prevailing for membership for the I.C.I., and I hope that others will follow.

Adaptability to New Circumstances

Progress in the science of light production and the art of its application will continue, and new subjects will appear in the course of time on the list of Secretariat Committees. It may be necessary to have intermediate Committee meetings, like that in Zurich in 1932 which dealt with aviation lighting in a period when night flying became a necessity. It may prove necessary to issue interim reports on certain subjects. For example, fluorescent lighting has brought about some problems connected with the standardisation of dimensions, notably length, of the colour and of the terminology for the colour of light. Happily the organisation of the I.C.I. has proved to have the adaptability for dealing adequately with such problems.

Problems Unsolved

Each of the 24 subjects on which the I.C.I. Secretariat Committees have now started to work present some unsolved problems. One by one the best solutions will be found. Technical information will be collected, compared and analysed, the subject will be looked at from different angles, by various National Committees, until at last a basis for agreement is obtained and some recommendation can be framed.

One of these unsolved problems is the preparing of a list of recommended intensities of illumination for different kinds of work. Such lists have been in existence in many countries for a long time already. They are far from uniform in the values they recommend, even in one and the same country the recommended illumination values have increased in the course of the years. They have done so, because the efficiency of the light-sources increased. They are influenced by economic conditions, they are the result of an attempt to obtain a balance between the cost of lighting and its value for production, expressed in wages saved.

Both cost of light and wages are different in various countries, and it will be difficult to include these in a formula for the recommended intensity of illumination.

The "relative performance," introduced by Mr. H. C. Weston in his studies about the relation between illumination and visual efficiency, may offer a solution for this problem. It has become possible to establish a number of lists of recommended illumination values, each based on a different "relative performance," say 95 per cent., 90 per cent., 85 per cent., 80 per cent. This would correspond to a classification of such lists, the first one, with 95 per cent. relative performance, providing "very best" lighting, the one with 90 per cent. very good lighting, the one with 85 per cent. reasonable lighting.

Any country might then select that list, which corresponds to the class of lighting it can afford to have from an economic point of view.

One of the unsolved problems remains the limitation imposed by the Statutes

of the I.C.I. to the use of three languages (French, English, German), and the use of one official language (French) for minutes and recommendations.

A considerable number of delegates are thereby excluded from expressing themselves in their own language, and every delegate has to rely upon his knowledge of these three languages or upon the resumee's, made by the translators in the remaining two languages.

Illuminating Engineering seems to be a subject which has not yet appealed to the professional translators. In a leading technical journal appearing in my country, I recently found, to my great surprise, the following translation of news about the work of the Bureau International des Poids et des Mesures in Paris:

"Since 1909 the unit of the light is the international candle, which is kept by the 'Conservatoire des Arts and des Meliers' in the form of an illuminated sphere of 1 m. diameter. The new candle which will be introduced on January 1, 1948, under the name of "Bouguer," will be 2 per cent. *shorter* than her predecessor."

At the first session of the I.C.I., which I attended at Bellagio, a German teacher from a Milan school was acting as translator. He only translated the generalities and the compliments to the authors of the papers, and he carefully refrained from entering into the technical subjects.

Some delegates then volunteered to help.

Their translations may have been less perfect from a linguistic point of view, but at any rate, they made clear the technical points.

This method of translating has been adhered to ever since, and I hope that there will always be delegates willing to co-operate in this way to a smooth running of the meetings, and to the efficiency of the I.C.I. work.

The translator may sometimes find himself in a difficult situation, e.g., when he discovers in a meeting on railway lighting that the word "signal box" has a different meaning for the American and the British delegates, the one considering it a booth from which the signals are operated, the other thinking that the object discussed is a luminous signalbox with coloured lens which can also be used in daylight.

Once a peculiar difficulty was caused by my ignorance about the way in which the Japanese reply to a question, put in the way of a negation. It happened at Cambridge, when I had to ascertain whether the Japanese agreed to a very obvious and acceptable proposal. So I asked in English: "You are not against the proposal, are you?" The Japanese delegate, smiling, replied, "Yes, we are." This meant: Yes, we are not against it, but I got the impression that they were in effect against it, and we lost some time in making things clear.

Doing such translating work may be a fatiguing job sometimes, but by thus giving yourself you also gain something. First of all the satisfaction of helping people to understand each other in the strict sense of the word. You also get a perfect hold of the subjects discussed, because the translator has to follow closely what is said. And, last but not least, the translator can save much time for everybody by just limiting himself to the essential points of the subject discussed.

I would not like you to get the impression that the translators are the only men who should give at such an occasion. All delegates to such an international meeting contribute to the success, the more so when they come with a spirit of *give*, instead of a spirit of *get*.

We all know that in our own circle we cannot have our own way, without

collisions and chaotic conditions. Well, the same applies to the national delegations to a session of the I.C.I. If they all want their own way results will be meagre.

To travel abroad, to meet and to know each other, is not sufficient for international understanding. It only brings you half way.

International relations are, indeed, the results of personal relations, but we have to attach a *deeper* sense to those words "human relations."

Ambition, pride and selfishness already form a strong obstacle to teamwork in family-life, in industry, and in everybody's daily work, they are absolutely *detrimental* to international relations.

I have seen this clearly in the delightful Moral Rearmament play, "The Statesman's Dream," where a statesman defending "sub-section X" of a treaty at the conference table against strong opposition, suddenly admits: "And by the way, I wrote it myself." In the end this statesman finds the real constructive ideas when he has learned to fight for "What is right" and not for "Who is right."

If all those who are working together in the I.C.I. and in its Technical Committees will produce in the same way constructive ideas, the I.C.I. may set a pattern for other international conferences in the fields of science, of economics and—even—of politics.

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

With a view to avoiding possible confusion with other publications, reference to these Transactions should be in the form:—"Trans. Illum. Eng. Soc. (London)."

The Reflexion Factor of Glass

By J. G. HOLMES, A.R.C.S., B.Sc., F.Inst.P., *(Fellow)*

Abstract

Figures are given for the reflexion factor of air-glass surfaces for directed light at several angles of incidence and for diffused light, making allowance for the effects of polarisation and multiple reflexion in a glass sheet. The definition of transmittance and the effects of a prismatic surface are discussed.

(1) Introduction

The usual figure for the reflexion factor of sheet glass is 8 per cent., or 4 per cent. for each surface, but this is only approximate, the correct figure varying with the refractive index of the glass and the angle of reflexion. Frosted glass and, in general, prismatic glass reflect more light than clear sheet glass because of the obliquity of the facets in the surface and because of the multiple internal reflexion which can occur. Figures for reflexion at a single surface have been given by Walsh (1).

In this note, the well-known formulae are re-stated and tables are given for the reflexion factors at several angles for typical refractive indices. The effects of plane polarisation of the incident and the transmitted light are considered in relation to multiple reflexion in sheet glass; the effects of absorption of light in the glass and the change of refractive index with wavelength being neglected. The overall reflexion factor for diffused light, the relation between transmission factor and transmittance and the effects of a prismatic surface are derived.

The calculated figures apply only to clear untarnished surfaces; the effect of tarnish may be either an increase or a decrease in the reflexion factor. The tilting plates used on the photometer bench as a means of control of brightness or intensity require individual calibration for accurate work, although the relation between reflexion factor and angle may be derived from formulae. The figures given in the tables have been calculated to five figures but, as the differences between relatively large quantities are involved, errors of a few units may be present in the fourth place. The angles of incidence for which figures are given were chosen as convenient for calculations in which the author was interested.

(2) Single Surface Reflexion

For normal incidence on a single air-glass surface, the reflexion factor (ρ_1) and the transmission factor (τ_1) are dependent on the refractive index (n) according to the relations:

$$\rho_1 = (n - 1)^2/(n + 1)^2 \quad \text{2.11}$$

$$\tau_1 = 4n/(n + 1)^2 \quad \text{2.12}$$

For oblique incidence, the reflexion factor is given by two terms (ρ'_1 and ρ''_1) relating to light which is plane-polarised in the two planes respectively parallel and normal to the plane of incidence:

$$\rho_1 = \sin^2(i - r)/\sin^2(i + r) \quad \text{2.21}$$

$$\rho'_1 = \tan^2(i - r)/\tan^2(i + r) \quad \text{2.22}$$

where i and r are the angles of the rays on the air side and the glass side of the surface respectively. Thus:

$$\sin i = n. \sin r$$

For unpolarised incident light, the two terms are of equal weight and the photometric reflexion factor (ρ_1) is given by:

$$\rho_1 = \tfrac{1}{2}(\rho'_1 + \rho'_1) \quad \text{..... 2.31}$$

Also $\tau_1 = 1 - \rho_1$ 2.32

In the tables, values are given for i, r, ρ'_1, ρ''_1 and for ρ_1 and τ_1 calculated from equations 2.3 for unpolarised incident light.

(3) Reflexion at Two Surfaces

For a sheet of glass or similar material with two parallel polished surfaces, the reflexion factor (ρ_2) is less than twice that for a single surface according to the general formula:

$$\rho_2 = 2\rho_1/(1 + \rho_1) \quad \text{..... 3.01}$$

Also: $\tau_2 = \tau_1/(2 - \tau_1)$ 3.02

These take account of multiple reflexion between the surfaces and, for normal incidence, lead to:

$$\rho_2 = (n - 1)^2/(n^2 + 1) \quad \text{..... 3.11}$$

$$\tau_2 = 2n/(n^2 + 1) \quad \text{..... 3.12}$$

For oblique incidence, the simple formula (3.01) is not admissible because light which is initially unpolarised becomes partly plane-polarised on transmission through the first surface and the two components must therefore be considered separately.

For the component polarised in the plane of incidence:

$$\rho'_2 = 2\rho'_1/(1 + \rho'_1) \text{ or } \quad \text{..... 3.21}$$

$$= 2\sin^2(i - r)/[\sin^2(i + r) + \sin^2(i - r)]$$

For the component polarised normal to the plane of incidence:

$$\rho''_2 = 2\rho''_1/(1 + \rho''_1) \text{ or } \quad \text{..... 3.22}$$

$$= 2\tan^2(i - r)/[\tan^2(i + r) + \tan^2(i - r)]$$

For unpolarised incident light:

$$\rho_2 = \tfrac{1}{2}(\rho'_2 + \rho''_2) \quad \text{..... 3.31}$$

In terms of transmission factor, the corresponding relations are:

$$\tau'_2 = \tau'_1/(2 - \tau'_1) = \frac{\sin^2(i + r) - \sin^2(i - r)}{\sin^2(i + r) + \sin^2(i - r)} \quad \text{.....3.23}$$

$$\tau''_2 = \tau''_1/(2 - \tau''_1) = \frac{\tan^2(i + r) - \tan^2(i - r)}{\tan^2(i + r) + \tan^2(i - r)} \quad \text{.....3.24}$$

Whence for unpolarised incident light:

$$\tau_2 = \tfrac{1}{2}(\tau'_2 + \tau''_2) \quad \text{.....3.32}$$

For partly polarised incident light, the relations are more complex but the reflexion or transmission factors may be readily calculated from the figures given in the tables.

As an example, the light reflected at 65° from the normal at a glass plate of refractive index 1.500 may be calculated as follows:—

$$i = 65°,\ n = 1.500,\ r = 37.17°$$

Single surface: $\rho'_1 = 0.2281$, $\rho''_2 = 0.0130$ whence $\rho_1 = 0.1205$ and $\tau_1 = 0.8795$

Double surface: $\rho'_2 = 0.3714$, $\rho''_2 = 0.0256$ whence $\rho_2 = 0.1985$ and $\tau_2 = 0.8015$

The reflexion factor of 0.1985 may be compared with the results of erroneous calculations as follows:—

No allowance for polarisation ..... $2\rho_1/(1+\rho_1) = 0.215$

No allowance for polarisation or multiple reflexion $2\rho_1 - \rho_1^2 = 0.226$

No allowance for reflexion loss at first surface..... $2\rho_1 = 0.241$

In the tables, values are given for ρ'_2 and ρ''_2 and for ρ_2 and τ_2 calculated from equations 3.3 for unpolarised incident light.

(4) Some Applications

(4.1.) Diffused Light

The transmission factor for clear flat glass or plastic sheet for diffused light may be obtained by integration of the figures in the tables, weighted according to the function sin i.cos i.di, and the results are given in Table 4. These figures are consistent with those given by Walsh(2).

The transmission factor for figured or prismatic glass is not readily calculable, but it may be shown that the transmission for fully diffused light is a maximum when the two surfaces have equal reflexion factors, from which it may be deduced that the diffuse transmission factor for parallel-sided glass is always greater than that for figured glass. This general conclusion is not applicable to directed light, either in the form of a beam or in the form of rays emanating from a small source of light, for which a prismatic pattern may be designed to give a higher transmission factor than clear glass.

(4.2.) Directed Light

Directed light incident on clear class is not scattered by transmission or reflexion, both of which are regular. With a prismatic pattern, however, there are both diffused and regular components, and the following examples are typical:—

Consider light directed at 65° from the normal on to a prismatic plate (n = 1.50) carrying linear prisms of 40° angle on its second surface. The reflected light may be shown by calculation to consist of 12.05 per cent. regularly reflected and 0.02 per cent. diffusely reflected, and the transmitted light to consist of 84.43 per cent. regularly transmitted, and 3.50 per cent. diffusely transmitted. The total transmitted flux is 87.93 per cent., which may be compared with 80.15 per cent. for clear sheet glass in the example in paragraph 3 above.

Consider light from a small uniform source at 3 in. from a 12 in. diameter glass plate (n = 1.50). If the plate is clear, the transmitted flux amounts to 90.38 per cent. of the flux incident on the plate, this figure being obtained by integrating the values of τ_2 from 0° to 63.43° in Table 1. If the plate carries ring-prisms or steps on its second surface designed to give a parallel beam of light, the transmitted light consists of 83.20 per cent. in the beam and about 9 per cent. diffused, making a total transmitted flux of 92.2 per cent. If the prisms are designed to give a beam of ± 36° divergence, the transmitted light consists of 91.0 per cent. in the beam and about 2 per cent. diffused, making a total transmitted flux of 93 per cent. If the prismatic plate were replaced by a plano-convex lens, the amount of light transmitted in the beam would be the same, but the amount of diffusely transmitted light would be reduced. The reflexion loss at a plate with prisms or with a convex lens on the first surface may be shown to be considerably greater than for a plate with prisms on the second surface. These principles are of course widely used in the design of lenses for lighthouses, signalling apparatus, and illuminating glass where high transmission factors are desired.

(4.3.) Transmittance

In some specifications for coloured glass(3), the loss of light by absorption in the material is controlled by placing a low limit on the transmittance. Transmittance is defined as the ratio of the amount of light in the beam from a coloured lens or a plain coloured glass, under specified conditions, to the

amount of light in the beam from an uncoloured, non-absorbing lens or plain glass of the same form and refractive index. The transmittance is therefore a property of the material, whereas the transmission factor, which is the ratio of the amount of light leaving the coloured lens (in the beam) to the amount incident upon it, is critically dependent on the form of the lens and on the conditions of the experiment as well as on the absorption in the material. In America(4), the name "transmittance" has the same meaning as our term "transmission factor."

The relation between transmittance and transmission factor may be calculated for plain flat coloured glass. If α is the proportion of light absorbed in a single passage through the glass, the following expressions may be stated for directed light:—

Reflexion factor:— $$\rho_1 . \frac{1 + (1 - 2\rho_1) \cdot (1 - \alpha)^2}{1 - \rho_1^2 \cdot (1 - \alpha)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 4.31$$

Transmission factor:— $$\frac{(1 - \rho_1)^2 \cdot (1 - \alpha)}{1 - \rho_1^2 \cdot (1 - \alpha)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 4.32$$

Transmittance:— $$\frac{(1 - \rho_1^2) \cdot (1 - \alpha)}{1 - \rho_1^2 \cdot (1 - \alpha)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 4.33$$

These relations are useful in estimating the effects of change of thickness of a coloured glass, because there is a simple relation between the absorption factor α and the thickness of the glass. When the absorption is considerable and α approaches unity, the effect of multiple reflexion is negligible in the coloured glass but is not negligible in the non-absorbing glass used in measuring transmittance. The transmittance of a dark flat glass is therefore $(1 - \rho_1^2) \cdot (1 - \alpha)$.

The transmittance of a prismatic glass is less readily calculated, but if it be assumed that the conditions of measurement relate only to the regularly transmitted (undiffused) light, the effects of multiple reflexion may be neglected for both absorbing and non-absorbing glasses leading to the expressions:—

Transmission factor:— $$(1 - \rho_1)^2 . (1 - \alpha) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 4.34$$

Transmittance:— $$(1 - \alpha) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 4.35$$

The transmittance of a prismatic glass is thus greater than that of a plain glass of the same absorption factor.

(5) Conclusions

The formulae for reflexion factor at single and double air-glass surfaces have been evaluated and applied to particular instances of plain, prismatic and coloured glass. For diffused light, the transmission factor of a figured glass is less than that of a clear glass, but the reverse may be true for directed light. The transmission factor of a beam-forming prismatic plate is greater if the second surface is figured rather than the first surface. The transmittance of a coloured glass is dependent on its reflexion factor as well as its absorption factor and, for a given absorption, the transmittance of a prismatic glass is slightly greater than that of plain glass.

References

(1) "Photometry," pp. 112-114, by J. W. T. Walsh. Constable, London, (1926).

(2) "The Transmission Factor of Commercial Window Glasses," by A. K. Taylor and C. J. W. Grieveson, with appendix by J. W. T. Walsh. D.S.I.R. Illumination Research Technical Paper No. 2 (1926).

(3) British Standard Specification 623-1940, "Colours for Railway Signal Glasses." British Standards Institution, London (1940).

(4) "Report of the Colorimetry Committee," J.O.S.A. 34, 246 (1944).

Table 1.

Reflexion and Transmission Factors for Refractive Index, n = 1.500

Angles		One surface				Two Surfaces			
i	r	ρ'_1	ρ''_1	ρ_1	τ_1	ρ'_2	ρ''_2	ρ_2	τ_2
0	0	0.0400	0.0400	0.0400	0.9600	0.0769	0.0769	0.0769	0.9231
10	6.65	0417	0384	0400	9600	0800	0739	0770	9230
12	7.96	0425	0377	0401	9599	0814	0726	0770	9230
15	9.94	0438	0363	0401	9599	0839	0700	0770	9230
20	13.18	0471	0335	0403	9597	0900	0648	0774	9226
24	15.73	0506	0306	0406	9594	0964	0594	0779	9221
30	19.47	0578	0253	0415	9585	1093	0493	0793	9207
36	23.07	0680	0189	0435	9565	1274	0372	0823	9177
45	28.13	0920	0085	0502	9498	1685	0168	0926	9074
48	29.70	1033	0052	0542	9458	1872	0103	0988	9012
50	30.71	1120	0033	0577	9423	2015	0065	1040	8960
55	33.10	1393	0002	0697	9303	2445	0004	1224	8776
56.31	33.69	1480	0000	0740	9260	2577	0000	1289	8711
58	34.43	1602	0003	0803	9197	2761	0007	1384	8616
60	35.26	1765	0018	0892	9108	3003	0036	1519	8481
65	37.17	2281	0130	1205	8795	3714	0256	1985	8015
68	38.18	2681	0277	1479	8531	4228	0538	2383	7617
70	38.79	2996	0425	1710	8290	4611	0815	2713	7287
75	40.09	3993	1068	2530	7470	5707	1929	3818	6182
78	40.70	4773	1740	3256	6744	6462	2963	4712	5288
79	40.88	5069	2033	3551	6449	6728	3378	5053	4947
80	41.04	5386	2368	3877	6173	7001	3830	5416	4584
81	41.18	5724	2752	4238	5762	7281	4317	5799	4201
85	41.61	7324	4932	6128	3872	8455	6606	7531	2469
86	41.68	7793	5688	6741	3259	8760	7252	8006	1994
88	41.77	8827	7548	8188	1812	9377	8603	8989	1011
90	41.81	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000

Table 2.

Reflexion and Transmission Factors for Refractive Index, n=1.520

Angles		One Surface				Two Surfaces			
i	r	ρ'_1	ρ''_1	ρ_1	τ_1	ρ'_2	ρ''_2	ρ_2	τ_2
0°	0°	0.0426	0.0426	0.0426	0.9574	0.0817	0.0817	0.0817	0.9183
10	6.56	0444	0409	0426	9574	0849	0786	0818	9182
15	9.80	0466	0387	0427	9573	0890	0746	0818	9182
20	13.00	0500	0357	0428	9572	0952	0689	0821	9179
30	19.20	0612	0271	0441	9559	1154	0528	0840	9160
45	27.72	0967	0094	0530	9470	1764	0186	0975	9025
55	32.61	1453	0003	0728	9272	2538	0006	1272	8728.
56.66	33.34	1567	0000	0783	9217	2710	0000	1355	8645
60	34.73	1834	0015	0924	9076	3100	0030	1565	8435
65	36.60	2357	0123	1240	8760	3815	0243	2029	7971
70	38.19	3079	0415	1747	8253	4709	0797	2753	7247
75	39.46	4078	1056	2572	7428	5790	1910	3850	6150
79	40.23	5150	2020	3585	6415	6798	3360	5079	4921
80	40.38	5464	2355	3910	6090	7066	3813	5440	4560
81	40.53	5798	2740	4269	5731	7340	4301	5821	4179
85	40.95	7373	4922	6147	3853	8488	6596	7542	2458
86	41.02	7838	5679	6758	3242	8788	7244	8016	1984
90	41.14	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000

Table 4.

Transmission Factors of Sheet Glass

Refractive Index	1.500	1.520
Directed Light incident normally :		
Single Surface	0.9600	0.9574
Double Surface	0.9231	0.9183
Unpolarised Diffused Light (2) :		
Single Surface	0.9082	0.9050
Double Surface	0.850	0.845
Unpolarised Diffused Light in 45°–90° zone :		
Double Surface	0.780	0.775
Unpolarised Diffused Light in 45°–90° octant (2) :		
Double Surface	0.71	0.70

Table 3.

The Effect of Refractive Index on Reflexion and Transmission Factors

Refractive Index	i	r	ρ'_1	ρ''_1	ρ_1	τ_1	ρ'_2	ρ''_2	ρ_2	τ_2
1.4	0°	0°	0.0278	0.0278	0.0278	0.9722	0.0541	0.0541	0.0541	0.9459
	10	7.12	0290	0266	0278	9722	0564	0518	0541	9459
	20	14.14	0331	0229	0280	9720	0641	0448	0544	9456
	30	20.92	0413	0168	0290	9710	0793	0331	0562	9438
	54.46	35.54	1052	0000	0526	9474	1905	0000	0952	9148
1.50	0°	0°	0.0400	0.0400	0.0400	0.9600	0.0769	0.0769	0.0769	0.9231
	10	6.65	0417	0384	0400	9600	0800	0739	0770	9230
	20	13.18	0471	0335	0403	9597	0900	0648	0774	9226
	30	19.47	0578	0253	0415	9585	1093	0493	0793	9207
	56.31	33.09	1480	0000	0740	9260	2577	0000	1289	8711
1.52	0°	0°	0.0426	0.0426	0.0426	0.9574	0.0817	0.0817	0.0817	0.9183
	10	6.56	0444	0409	0426	9574	0849	0786	0818	9182
	20	13.00	0500	0357	0428	9572	0952	0689	0821	9179
	30	19.20	0612	0271	0441	9559	1154	0528	0840	9160
	56.66	33.34	1567	0000	0783	9217	2710	0000	1355	8645
1.54	0°	0°	0.0452	0.0452	0.0452	0.9548	0.0865	0.0865	0.0865	0.9135
	10	6.47	0471	0434	0453	9547	0899	0833	0866	9134
	20	12.83	0530	0380	0455	9545	1006	0732	0869	9131
	30	18.95	0646	0289	0468	9532	1214	0563	0888	9112
	57.00	33.00	1655	0000	0827	9173	2840	0000	1420	8580
1.6	0°	0°	0.0533	0.0533	0.0533	0.9467	0.1011	0.1011	0.1011	0.8989
	10	6.23	0553	0512	0533	9467	1049	0975	1012	8988
	20	12.34	0620	0451	0536	9464	1168	0863	1015	8985
	30	18.21	0751	0348	0550	9450	1397	0673	1035	8965
	57.99	32.01	1921	0000	0960	9040	3222	0000	1611	8389
1.7	0°	0°	0.0672	0.0672	0.0672	0.9328	0.1260	0.1260	0.1260	0.8740
	10	5.86	0696	0648	0672	9328	1302	1271	1260	8740
	20	11.61	0776	0575	0675	9325	1440	1087	1263	8737
	30	17.10	0928	0452	0690	9310	1698	0866	1282	8718
	59.54	30.46	2360	0000	1180	8820	3817	0000	1909	8091
1.8	0°	0°	0.0816	0.0816	0.0816	0.9184	0.1509	0.1509	0.1509	0.8491
	10	5.53	0845	0788	0816	9184	1558	1461	1510	8490
	20	10.95	0934	0705	0820	9180	1709	1316	1513	8487
	30	16.13	1106	0564	0835	9165	1992	1067	1530	8470
	60.94	29.06	2792	0000	1396	8604	4367	0000	2184	7816

THE ANNUAL GENERAL MEETING

The annual general meeting of the Illuminating Engineering Society took place at the Institution of Mechanical Engineers, Storey's Gate, London, S.W.1, at 6 p.m. on Tuesday, May 13, 1947.

The Secretary, having read the notice convening the meeting and also the statement of the auditors for the past year, it was agreed that the minutes of the last meeting be taken as read and approved.

The President, presenting the Report of the Council and statement of accounts for 1946, said the position generally could be considered a very satisfactory one. The Society had passed through a somewhat critical period with wonderful ease, largely due to the acceptance by Mr. H. C. Weston of the duties of Honorary Secretary, a position which he would continue to fill for the next year.

The Hon. Secretary (Mr. H. C. Weston) said the year under review had been an exceptional one in various ways. The Society had not escaped all the difficulties and limitations of the post-war period, but nevertheless records had been established in the membership and in the activities of the Society. The double award of the Leon Gaster Memorial Premium was an indication of the increasing standard of excellence of papers read before the Society. The Society had also been fortunate in securing the services of Dr. S. English as Hon. Editor of the Transactions, a position which, with the development of the Transactions which was envisaged as soon as conditions permit, might well severely tax the generosity of Dr. English in the matter of time and effort.

Mr. Percy Good (Hon. Treasurer), dealing with the accounts, said that the position was a very satisfactory one. The subscriptions, which were really the test of the growth of the Society, had made a satisfactory and appropriate increase, and the increase on the expenditure side was a natural indication of the Society's increased activities.

Adoption of Report and Accounts

The following resolution was then put to the meeting by Mr. C. R. Bicknell and seconded by Mr. C. I. Winstone:—

> That the Report of the Council and the accounts of the Illuminating Engineering Society for the period January 1, 1946, to December 31, 1946, be hereby adopted, and that a vote of thanks be extended to the President, Council, and Officers for their efforts on behalf of the Society during the past year.

On being put to the meeting the Report was declared carried unanimously.

The President, on behalf of the Officers and Council, expressed his appreciation of the vote of thanks.

On the proposal of Mr. S. Anderson, seconded by Mr. Alan H. Owen, Messrs. Robert Ward and Co. were unanimously re-elected as auditors of the Society for the year ending December 31, 1947.

Election of Officers and Council

The Hon. Secretary reported that there had been no independent nominations, and the Council's nominations for Officers and members of Council therefore stood. Those elected were as follows:—

President: Dr. J. W. T. Walsh.
Vice-Presidents: Mr. J. M. Waldram, Mr. J. S. Preston, Dr. E. C. Walton.
Hon. Treasurer: Mr. J. G. Holmes.
Hon. Seretary: Mr. H. C. Weston.
Hon. Editor of Transactions: Dr. S. English.
Members of Council: Mr. C. R.

Bicknell, Mr. Harold Bright, Mr. S. D. Lay, Mr. H. A. Lingard, Dr. J. H. Nelson, Mr. J. S. Smyth, Mr. J. F. Stanley, Mr. P. Crawford Sugg.

Register of Lighting Engineers (I.E.S.)

The President then announced the result of the ballot which had recently taken place in regard to the Register of Lighting Engineers. The total number of votes in favour of the proposal was 443, the number of votes against being 31. The proposal to form a Register of Lighting Engineers was therefore carried, and, in accordance with the Articles of Association, the changes in the By-laws would take effect 21 days after the meeting. A certain amount of time would be required to prepare the working details of the scheme, but the Council would expedite the matter to have the scheme operating as quickly as possible.

This terminated the formal business.

International Relations in Illuminating Engineering

At the subsequent sessional meeting Dr. Halbertsma opened his address with a review of the history and development of the International Commission on Illumination, of which he is President. He also explained the organisation of the executive committee and of the various National Committees of the members' countries, and showed how tasks were allotted to each country and how reports were collected and prepared.

Since its first technical meeting, which was held in Paris in 1921, the I.C.I. has continued to grow and is being more and more accepted as the authoritative body in the field of illumination. Reasons for this may be that the I.C.I. is a free body and not an inter-government concern, whilst the Executive Committee and Administration of the I.C.I. have always been willing to co-operate with other international bodies.

At present, he said, a great volume of the work falls upon a few countries, as during the war contact was lost with some of the member countries, though it was hoped to re-establish contact with these, and other countries, in the near future. Throughout the world, he said, there was a demand for an extensive survey of all lighting literature issued in the period 1938-47, and it was hoped that the Secretariat Reports for the eleventh I.C.I. Session, to be held in Paris in 1948, would answer this need. Dr. Halbertsma concluded with some remarks on problems still to be solved by the Commission.

Sir Clifford Paterson, in proposing a vote of thanks to Dr. Halbertsma for his address, said that the I.C.I. owed more to Dr. Halbertsma than to any other person. It had also gained enormously by having the secretarial office located at the National Physical Laboratory at Teddington, and through the excellent arrangement whereby the General Secretaryship had passed from Dr. Walsh to Dr. Buckley, and then to Dr. Stiles, and then to Mr. Preston, thus ensuring continuity of the work. At the end of his address Dr. Halbertsma had mentioned the future work of the Commission, and had pointed out that there was no recognised international set of illumination values for different tasks, and he personally wondered why it had not been possible to get something more definite in that direction.

One matter to which illuminating engineers should give careful consideration was how relative performance was affected by age. It was not generally realised that as people grow older they need higher levels of illumination. It was necessary, therefore, to obtain some correlation between age and the amount of light needed to carry out definite tasks, and he thought that we would find the results of great interest. In conclusion, Sir Clifford repeated his appreciation, on behalf of the meeting, of

the inspiring address which they had had the pleasure and privilege of hearing.

Mr. Percy Good, in seconding the vote of thanks, said that those who had had the privilege of meeting Dr. Halbertsma at the various meetings of the I.C.I. would agree that his Presidency of the Commission at the present time was a good augury for the future. His marvellous facility of language had been a constant source of strength, whilst his cheerfulness and great ability had always been a great asset. We were now faced with the need for joining up the strings of internationalism, which had been attenuated during the last few years. Those interested in the arts and sciences had gained a great deal from these international gatherings, which, though often argumentative, had been free from unpleasant strife. Dr. Halbertsma's address gave a very fine lead-off for starting all that work again.

Confirming what Dr. Halbertsma had said, Mr. Good said that it was necessary to impress upon all the National Committees, and the various countries, that the strength of the international body was made up of the strength of the individual National Committees. If the strength of the committees in other countries could be made similar to those in Great Britain and Holland, then the work of the Commission would proceed much more rapidly.

The vote of thanks was passed with acclamation and the meeting terminated.

SESSIONAL MEETING IN LONDON

A Sessional Meeting was held at the School of Hygiene and Tropical Medicine, Keppel-street, Gower-street, London, W.C.1, at 6 p.m. on Tuesday, April 15, 1947.

Mr. J. S. Dow (President) was in the chair.

The minutes of the last meeting having been taken as read and confirmed, the President introduced the authors of the five papers on searchlights and associated problems which were to be presented at the meeting. The papers to be presented were as follows:—

1. "The Function and Design of Army Searchlights," by Mr. E. W. Chivers and Mr. D. E. H. Jones.
2. "High Power Searchlights Capable of Wide Divergence," by Air Commodore W. Helmore, Dr. H. K. Cameron, Dr. F. S. Hawkins, Mr. L. B. W. Jolley, and Mr. L. M. King-Brewster.
3. "Photometry of Searchlights," by Dr. H. K. Cameron, Dr. E. H. Rayner, Mr. E. R. Thomas, and Mr. G. T. Winch.
4. "The Visibility of Targets in a Naval Searchlight Beam," by Mr. W. D. Chesterman and Dr. W. S. Stiles.
5. "Some Visibility Problems Associated with Anti-Aircraft Searchlight Beams," by Mr. S. S. Beggs and Mr. J. M. Waldram.

The President then called upon the various authors in turn to present their papers. Owing to the large number of papers each was limited to a period of twelve minutes, during the course of which the paper was presented in summary and illustrated by lantern slides and demonstrations.

After a vote of thanks, proposed by the President, had been carried, the discussion was opened by Commander C. J. Carr, who was followed by Dr. W. M. Hampton, Sir Clifford Paterson, Dr. J. W. T. Walsh, Dr. J. N. Aldington, Professor J. T. MacGregor Morris, and Mr. H. F. Stephenson. The authors replied to the various points raised on their own papers, after which the meeting was terminated.

Special Searchlight Symposium

At a meeting in London on April 15, 1947, the Society made an entirely new departure in arranging for no fewer than five papers on associated subjects to be presented. In what follows a summary of these papers is given, but the full text will appear in a special brochure which will be published in a limited edition and will also include additional written contribution.

The Function and Design of Army Searchlights

By E. W. CHIVERS, B.Sc., and D. E. H. JONES, M.Sc., A.M.I.E.E., A.Inst.P.

The development of searchlights is traced from the end of the 1914-18 war up to the present day. The factors affecting the design, with regard to the particular use of the various types, are discussed and some military applications are detailed. The various factors determining the beam characteristics are considered. A method of assessing the accuracy of reflectors, mounted in searchlights, by flash testing is described and some results are given. The maximum tolerances desirable in focus lamp gauge control and source and reflector alignment are also discussed.

Some full-scale field tests for comparing the visual ranges of various sizes of searchlights under specified conditions are described for a static target method and for an aircraft target method. Some of the results obtained are given.

The development of the carbon arc from low current density arcs to the present high current density arcs is traced and the design of Army searchlight arc lamps considered.

The 150 cm. anti-aircraft searchlight is described as an example of the stage now reached in a particular application.

The various methods of searchlight control used by the Army are detailed and finally the main types of searchlights in service are briefly described.

High-Power Searchlights Capable of Wide Divergence

By Air Commodore W. HELMORE, C.B.E., Ph.D., M.Sc., F.C.S., H. K. CAMERON, Ph.D., F.R.I.C., F. S. HAWKINS, Ph.D., A.R.I.C., L. B. W. JOLLEY, M.A., M.I.E.E., and L. M. KING-BREWSTER, M.A., B.A.I.(Elec. and Mech.), A.M.I.E.E.

The development of a searchlight carried by a fast fighter aircraft and used for illuminating enemy bombers is described in the first part of the paper. It is shown that the operational requirements could be met by the employment of a beam of elliptical cross-section having a horizontal divergence of 30° and a vertical divergence of 7°, but it was found that the required flux intensity could only be obtained by the use of a high current density carbon arc larger in size than any previously known of this type. The development and photometry of an arc lamp burning 37 mm. positives at 1,400 amperes, 140 kilowatts, is described and an account is given of the unexpected changes in the nature of the arc at these currents. Details are also given of the effect of reduction of atmospheric pressure such as would be experienced at altitude on the character and light output of the arcs employed. Finally there is a brief description of the installation of the projector and its secondary battery power supply in aircraft.

The second part of the paper covers the development of a ground searchlight of high power. The requirement of a divergence of about 6° was met by the use of an arc burning a 64 mm. positive at 4,000 amperes, 600 kilowatts in a projector having a parabolic mirror 156 cm. in diameter. Brief details are given

of the water-cooled arc lamp and projector used, and preliminary experiments with a projector fitted with a parabolic mirror 300 cm. in diameter are described.

The results of photometric measurements are given in each case, a peak beam intensity of 2,700 megacandles being achieved with the 300 cm. mirror. Finally an analysis is given of the optical effects of defocusing the source in these projectors, for it was an operational requirement that the divergence of the beam from these projectors should be increased or decreased at will.

Photometry of Searchlights

By H. K. CAMERON, Ph.D., F.R.I.C., E. H. RAYNER, Sc.D., E. R. THOMAS, B.Sc.(Eng.), A.M.I.E.E. *(Member)*, and G. T. WINCH, M.I.E.E., F.Inst.P. *(Fellow)*

The work described in this paper formed part of a development programme on light sources.

A description is given of new methods and apparatus which have been devised in order to facilitate the measurement, appraisal and correlation of sources, optical systems, and beam performance of searchlights.

Details are given of apparatus and methods for the rapid measurement of candle-power, source brightness, distribution, and mirror characteristics.

Various developments in photoelectric telephotometric apparatus suitable for making beam intensity measurements by daylight are described, and typical distribution curves obtained by these means are given, including a method for correlating the characteristics of the light source and optical system, and an example is given showing close agreement between estimated and measured beam performance.

Measurements of beam intensity distribution made over photometric ranges of 1,500 and 5,000 ft. confirm theoretical calculations that, provided the projector is focused for optimum flash at the range at which measurements are made and not to infinity, no significant differences in beam intensity or distribution are observed at the different distances.

Further results obtained by these methods are detailed in collateral papers.

The Visibility of Targets in a Naval Searchlight Beam

By W. D. CHESTERMAN, B.Sc., F.Inst.P., and W. S. STILES, D.Sc., Ph.D. *(Fellow)*

In the naval use of searchlights it is of importance to know before exposing a beam laid by non-visual methods whether the target will be immediately visible. The investigation described in this paper is concerned primarily with determining the answer to this question when certain information is given about (a) the nature and position of the target, (b) the searchlight characteristics and observing conditions, and (c) the state of the atmosphere. The work falls into three parts: (i) the calculation of the apparent brightness of the beam and the brightness difference presented by a target for a wide range of possible conditions, (ii) the simulation in the laboratory of these calculated brightness distributions and the determination of laboratory observations of those conditions under which the target is immediately visible, (iii) the calculation, using the results of (i) and (ii) of the way in which the distance within which the target is immediately visible depends on all the relevant variables. The results are presented in the form of range tables, and the effect on range of changing a particular variable, for example, beam divergence or atmospheric transmission,

keeping the other variables constant, is summarised in a series of empirical laws.

Some Visibility Problems Associated With Anti-Aircraft Searchlight Beams

By S. S. BEGGS, M.A. *(Member)*, and J. M. WALDRAM, B.Sc., F.Inst.P. *(Fellow)*

This paper examines three visual problems associated with the anti-aircraft searchlight: the conditions in which a target in the beam can be seen from a position on the ground adjacent to the light, the ranges at which such a target can be seen from a fighter aircraft at about the same altitude as the target, and the ranges at which the beam itself can be seen from the air in various conditions and orientations. The investigations are made mathematically, based upon data of the photometric properties of the atmosphere, of the visibility of small objects, and on the photometry of searchlights. Graphical methods of calculation are used in the first problem, which permit the calculation of off-axis targets and of asymmetrical beam distribution as well as atmospheric properties which change along the length of the beam. Three searchlights of different sizes have been investigated taking the data as measured for three actual atmospheres, which showed changes in both amount and type of scatter with altitude. The controlling factor in all three problems is the atmosphere; in the first problem particularly it may bring about unexpected effects with a black target, which are not important in the case of the naval searchlight. The effects of changes in the characteristics of the searchlight are examined and the relative performances of the three types investigated are discussed, so far as concerns the above three questions.

Programme of Meetings in London—Session 1948-49

The programme of papers to be read at sessional meetings in London during the session 1948-49 is now being prepared, and the Papers Committee invite offers of papers for inclusion in this programme.

Attention is drawn to "Recommendations to Authors of Papers for Presentation before the Society," which was published in the *Transactions*, September, 1945, and to the statement by the Papers Committee "Contributions to the *Transactions*," which appeared in the *Transactions* for April, 1946. In the first instance, authors submitting papers for the consideration of the Papers Committee should forward a summary (approximately 400 to 500 words in length) of their paper.

BINDERS FOR TRANSACTIONS

A supply of spring binders for *Transactions*, similar in construction and appearance to those previously supplied, though of a size suitable for the present form of *Transactions*, is now available. Great difficulty has been experienced in getting materials for such binders, and, though a limited supply has now been obtained, production costs are unavoidably higher than they were in pre-war years. Members will, however, no doubt be glad to avail themselves of the opportunity to bind their copies of the *Transactions* in this way and so preserve them in good condition. Binders will be supplied to members at the cost of 6s. 6d. each (7s. 6d. each to non-members).

Additions to List of Members

The following applicants have been duly elected by the Council to membership in the Society, and their names have been added to the list of members:—

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